(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 March 2001 (29.03.2001)

PCT

(10) International Publication Number
WO 01/22014 A1

(51) International Patent Classification[7]: F25D 21/00, F25B 47/02

(21) International Application Number: PCT/TR00/00051

(22) International Filing Date:
25 September 2000 (25.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1999/02355 24 September 1999 (24.09.1999) TR

(71) Applicant *(for all designated States except US)*: ARÇELIK A.Ş. [TR/TR]; AR-GE Dept., E5 Ankara Asfalti Üzeri, Tuzla, 81719 Istanbul (TR).

(72) Inventors; and

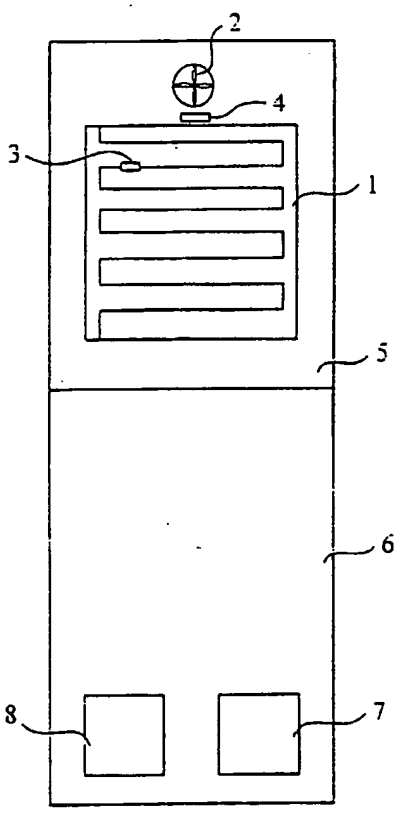
(75) Inventors/Applicants *(for US only)*: USTA, Halime [TR/TR]; c/o Arçelik A.Ş., E5 Ankara Asfalti Üzeri, Tuzla, 81719 Istanbul (TR). GÜLDALI, Yalçin [TR/TR]; c/o Arçelik A.Ş., E5 Ankara Asfalti üzeri, Tuzla, 81719 Istanbul (TR). HOCAOGLU, Sabahattin [TR/TR]; c/o Arçelik A.Ş., E5 Ankara Asfalti Üzeri, Tuzla, 81719 Istanbul (TR).

(74) Agent: ANKARA PATENT BUREAU LTD.; Sehit Adem Yavuz Sokak 8/22, Kizilay, 06440 Ankara (TR).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

[Continued on next page]

(54) Title: DEFROST CONTROL



(57) Abstract: The evaporator (1), fan (2) and two temperature sensors (3 and 4) are placed in an intermediate compartment in the freezer compartment (5) of a refrigerator with two compartments. One of the said sensors is disposed on the freezer evaporator (1) fluid inlet zone, and the other is placed at the flow area on the evaporator (1) air exit channel wherein the cooled air is blown by a fan (2). At the end of the time interval (t1) that starts as of the compressor (7) starts to operate, the temperature value (T1) detected by the sensor (4) placed at the flow area on the evaporator (1) air exit channel wherein the cooled air is blown by a fan (2) and the temperature value (T2) detected by the sensor (3) disposed on the freezer evaporator (1) fluid inlet zone are read during the time interval (t2) determined by the manufacturer.

WO 01/22014 A1

(84) **Designated States** *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— *With international search report.*

— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

DEFROST CONTROL

The present invention is related to starting a defrosting operation in the refrigerators by evaluating the temperature values obtained by two temperature sensors disposed in the freezer compartment.

Frost accumulation on the evaporators, which may occur in the refrigerators due to such reasons as frequent door opening/closing loading with food etc, causes a drop in the efficiency and the performance of the evaporator. In order to avoid this undesired condition, defrosting is effected periodically to melt the accumulated frost. Defrosting cycles effected before required, have a negative impact on the energy consumption both with regard to the power supplied to the heater switched on during this period and to the thermal load provided by the heater to the refrigerator. As the defrosting periods are determined in general for the worst loading conditions, this may cause a frequent defrosting of the evaporator although not required. For this reason, taking the decision to start the defrosting operation when it is needed is very important.

In the state of art, the decision for defrosting is taken according to the running period of the compressor. A timer controls the running period of the compressor and the decision for defrosting is taken when the defined period is completed. However in this technique, it cannot be determined whether the frost accumulated on the evaporator surface is at the threshold level to have a negative impact on the cooling performance of the refrigerator or whether a defrosting operation is definitely required or not. For an accurate determination, such factors as the ratio of user's using of the refrigerator, environmental conditions and the opening /closing of the refrigerator door, have to be taken into consideration, and the effects of the said factors on the cooling performance and frost accumulation have to be defined.

In the European Patent Application No. 0285690, another state of art is mentioned. In this technique, the temperature of the fluid at the entrance to the evaporator is compared to a given comparison value in order to decide to start the defrosting operation and if the measured value is greater than another comparison value, the defrosting operation is terminated. In an alternative method employed in this technique, the temperatures of the fluid at the inlet and exit of the evaporator are measured and the difference between them is calculated. In case this difference value is greater than a given comparison value, a certain time period is provided, and at the end of this period, decision for defrosting is taken when the said difference value increases with a defined temperature and when the temperature of the fluid entering the evaporator, exceeds a defined value, the defrost operation is terminated.

In the European Patent Application No. 0494785, a defrosting decision with warning is taken by using at least one or two temperature sensors connected with each other in series, and an electronic control unit. The sensors are the semi-conductor circuits sensing the temperature inside the refrigerator and they are connected to the electronic control unit. In the method, where a single temperature sensor is used, the sensor is placed inside the compartment. When the temperature value obtained from the sensor, reaches to a predetermined maximum value, defrosting is started. In the method where two sensors are used, first sensor is placed on the evaporator and the second is placed inside the compartment. By means of the four potentiometers, the inner temperature value of the compartment, the temperature value above the evaporator required for starting and terminating, and the temperature value to activate the fan upon the termination the defrosting operation, is loaded to the control unit.

In the state of art disclosed in EP Application No. 0803690, the decision for defrosting is given according to the temperature outside the cooler, also considering the differences between the rates of variations in temperature falls on the evaporator under frost or no-frost conditions. The time interval required for

cooling the air inside the refrigerator, also depends on the ambient temperature. A temperature sensor is placed in the refrigerator, on the evaporator or somewhere else, in order to obtain a reference for cooling time. The time interval spent to attain the desired temperature in the refrigerator when the compressor starts to operate, is called the cooling time. This time interval depends on the ambient temperature and the amount of frost load deposited on the evaporator. The time interval required for defrosting, as calculated when the compressor is not switched on, is less accurate than that calculated while the compressor is working. It is obvious that cooling efficiency and rate will be low in cases when a large quantity of frost has accumulated. The data obtained, are recorded in a microprocessor and the decision for starting and duration of the defrosting operation is taken by calculating the amount of frost deposited on the evaporator.

In the US Patent No. 5257506, decision for defrosting is taken by examining the evaporator outer temperature and the ambient temperature.

In the US Patents Nos. 4850204 and 4884414, the decision for defrosting is taken similar to the US Patent No. 5257506, but the decision is taken when the difference between the temperature on the evaporator and the ambient temperature exceeds a certain threshold value.

In the European Patent Application No. 0364238, the method used is related to the employment of defrosting adaptive to heat pumps, and consists of devices measuring the amount of frost deposited on the heat pump and consists of devices measuring the amount of frost deposited on the heat pump. In this method, defrosting operation is started when the difference between the ambient temperature and the temperature on the evaporator exceeds the value of a function depending on the external, ambient temperature. The defrosting time is measured, in case the time interval deviates from the predetermined period, the difference function is determined with respect to the ambient temperature, changes. The difference function for a certain ambient temperature, used for the calculation of

the quantity of frost that has been defined linearly at the beginning, can be drawn upwards or downwards depending on whether the defrosting time is longer or shorter than determined threshold values.

In the European Patent Application No. 0505315, the decision for defrosting is taken for a heat pump. Defrosting is started according to the temperature measured by a sensor on the evaporator and to the temperature of the fluid in the evaporator.

In US Patent No. 4292813, the decision for defrosting is taken according to the rate of the times when the compressor operated and its idle times.

In the US Patent No. 4689965, the rate of change of the temperature on the evaporator during a defrosting cycle, the time interval when the rate of change of the temperature of the evaporator remains constant and the duration of the cooling cycle depending on the determined time interval, are used. The determined time interval is indicative of the magnitude of next cooling cycle is calculated according the said magnitude of the frost load deposited on the evaporator.

In the European Patent Application No. 0740809, the freezer and cooling compartments of the refrigerator are cooled separately and independently. If the temperature in the cooling compartment exceeds a predefined temperature, defrosting cycle is started according to the operational conditions of the compressor and the fan. The starting time for defrosting in the cooling compartment is determined according to the decrease of the temperature value inside the compartment, the same criteria are valid for the freezer compartment.

In the European Patent Application No. 0501387, the difference values between the evaporation temperature of the fluid contained in the evaporator and its temperature when leaving of the refrigerator, or the difference between air entrance temperature or air entrance temperature and the evaporation temperature,

are used. This difference value obtained, the fluid temperature measured when leaving the refrigerator and the evaporation temperature values are used to open and close the expansion valve. The difference between air inlet temperature and vaporization temperature is used for calculation of ideal defrost time interval. At the same time the decrease in the flow, in a certain predetermined time range is calculated accordingly. Under the light of these two criteria if the two threshold values are exceeded, the operation of the compressor and fan are stopped and the defrost heater is operated until the refrigerator attains the ambient temperature indicating that the frost deposited on the evaporator has melted.

There are a lot of developed and continuing studies related to taking the decision for starting the defrosting cycle. The difference of the present invention is that, this approach utilizes such factors the environmental conditions affecting the cooling performance of the refrigerator, different user behaviours and different loading conditions altogether for taking the decision for starting the defrosting cycle.

The object of the present invention is to provide a decision taking for starting the defrosting cycle in the refrigerators, according to the operation of the compressor and to the temperature values obtained by the two temperature sensors placed in the freezer compartment, also by considering such factors that influence the operational performance of the refrigerator, as different user habits and behaviours and different loading conditions.

The defrost control realized in order to attain the above mentioned object of the present invention is illustrated in the attached drawings, wherein:

Figure 1, is the general view of the refrigerator with the sensors placed on the evaporator and on the blowing area of the fan;

Figure 2, is the side view showing the freezer compartment of the refrigerator and the sensors; and

Figure 3, is the flow chart of the defrost control.

The components shown on the drawings have been enumerated separately as follows;

1. Evaporator
2. Fan
3. Temperature sensor placed on the freezer evaporator fluid entrance zone
4. Temperature sensor placed on the flow area over the evaporator air discharge channel, wherein the cooled air is blown by a fan,
5. Freezer compartment
6. Cooling compartment
7. Compressor
8. Condenser

The evaporator (1), fan (2) and two temperature sensors (3 and 4) are placed in an intermediate compartment in the freezer compartment (5) of a refrigerator with two compartments. One of the said sensors is disposed on the freezer evaporator (1) fluid inlet zone, and the other is placed at the flow area on the evaporator (1) air exit channel wherein the cooled air is blown by a fan (2).

The temperature value detected by the sensor (4) placed at the flow area on the evaporator (1) air exit channel wherein the cooled air is blown by a fan (2) is shown as (T1) and the temperature value detected by the sensor (3) disposed on the freezer evaporator (1) fluid inlet zone is shown as (T2). At the end of the time interval (t1) that starts as of the compressor (7) starts to operate, the temperature value detected (T1) by the sensor (4) placed at the flow area on the evaporator (1) air exit channel wherein the cooled air is blown by a fan (2) and the temperature value (T2) detected by the sensor (3) disposed on the freezer evaporator (1) fluid inlet zone are read during the time interval (t2) determined by the manufacturer.

At the end of this time interval (t2) determined by the manufacturer, the mean value for the (T1) and (T2) values obtained, during the time interval (t2) the average temperature value (T1) detected by the sensor (4) placed at the flow area on the evaporator (1) air exit channel wherein the cooled air is blown by a fan (2) is subtracted from the average value of the temperature value (T2) detected by the sensor (3) disposed on the freezer evaporator (1) fluid inlet zone in order to find a temperature difference value (ΔT). The temperature difference value (ΔT) is compared to a threshold value (ΔT threshold) determined by the manufacturer and if the calculated temperature difference value (ΔT) is smaller than the threshold value (ΔT threshold), it is turned to the first operational step wherein the running of the compressor is checked. If the calculated temperature difference value (ΔT) is greater than the threshold value (ΔT threshold), the defrosting cycle is initiated.

CLAIMS

1. A refrigerator characterized with the temperature sensors (3 and 4) one of the said sensors being placed on the flow area on the evaporator (1) air exit channel wherein the cooled air is blown by a fan (2) in order to detect the temperature of the air over the flow area of the fan, and the other sensor being disposed on the freezer evaporator (1) fluid inlet zone in order to detect the temperature on the evaporator (1).

2 A refrigerator as claimed in Claim 1, characterized in that, at the end of the time interval (t1) that starts as of the compressor (7) starts to operate, the temperature value (T1) detected by the sensor (4) placed at the flow area on the evaporator (1) air exit channel wherein the cooled air is blown by a fan (2) and the temperature value (T2) detected by the sensor (3) disposed on the freezer evaporator (1) fluid inlet zone are read during the time interval (t2) determined by the manufacturer and that at the end of this time interval (t2), the mean value for the (T1) and (T2) values obtained, during the time interval (t2) the average temperature value (T1) detected by the sensor (4) placed at the flow area on the evaporator (1) air exit channel wherein the cooled air is blown by a fan (2) is subtracted from the average temperature value (T2) detected by the sensor (3) disposed on the freezer evaporator (1) fluid inlet zone in order to find a temperature difference value (ΔT) which is compared to a threshold value (ΔT threshold) determined by the manufacturer and if the calculated the temperature difference value (ΔT) is smaller than the threshold value (ΔT threshold), it is turned to the first operational step wherein the running of the compressor is checked; otherwise, i.e. if the calculated temperature difference value (ΔT) is greater than the threshold value (ΔT threshold), the defrosting cycle is initiated.

Figure 1

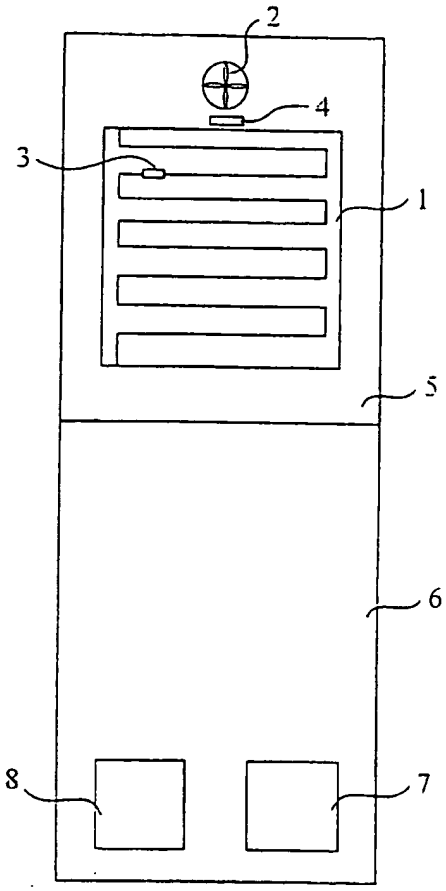


Figure 2

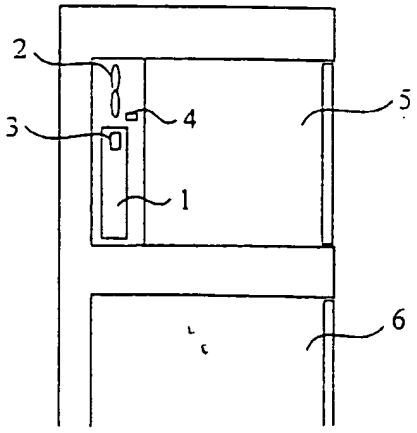
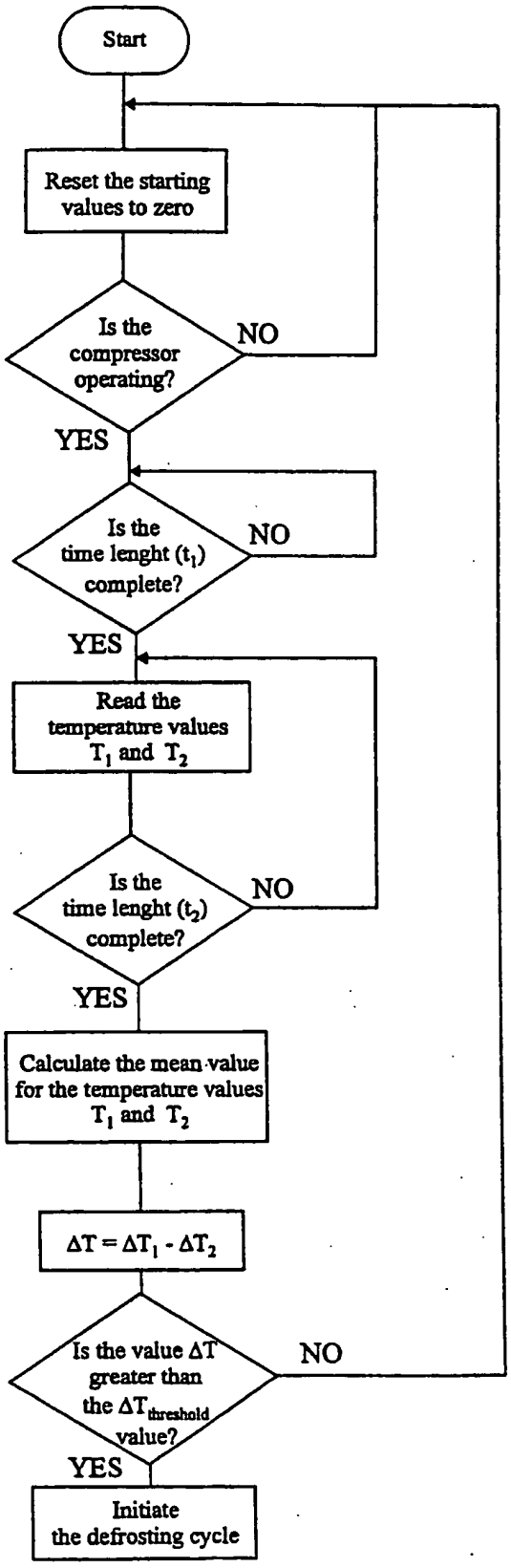


Figure 3


Start
Reset the starting values to zero
Is the compressor operating?
NO
YES
Is the time lenght (t_1) complete?
NO
YES
Read the temperature values T_1 and T_2
Is the time lenght (t_2) complete?
NO
YES
Calculate the mean value for the temperature values T_1 and T_2
$\Delta T = \Delta T_1 - \Delta T_2$
Is the value ΔT greater than the $\Delta T_{threshold}$ value?
NO
YES
Initiate the defrosting cycle

INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR 00/00051

CLASSIFICATION OF SUBJECT MATTER

IPC[7]: F25D 21/00; F25B 47/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[7]: F25D; F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2133867 A (NEWTECH CONTROLS Ltd.) 1 August 1984 (01.08.84) the whole document.	1,2
A	EP 0881440 A (R.C. CONDIZIONATORI S.p.A.) 2 December 1998 (02.12.98) the whole document.	1,2
A	EP 0142663 A (M.A.N. Maschinenfabrik) 29 May 1985 (29.05.85) fig. 1, claims.	1,2
A	US 5257506 A (DEWOLT) 2 November 1993 (02.11.93) the whole document.	1,2
A	US 4916912 A (LEVINE) 17 April 1990 (17.04.90) abstract, fig. column 5, lines 54-65.	1,2

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
„A" document defining the general state of the art which is not considered to be of particular relevance
„E" earlier application or patent but published on or after the international filing date
„L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
„O" document referring to an oral disclosure, use, exhibition or other means
„P" document published prior to the international filing date but later than the priority date claimed
„T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
„X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
„Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
„&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 January 2001 (05.01.2001)	20 February 2001 (20.02.2001)
Name and mailing adress of the ISA/AT Austrian Patent Office Kohlmarkt 8-10; A-1014 Vienna Facsimile No. 1/53424/535	Authorized officer WITTMANN Telephone No. 1/53424/380

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/TR 00/00051

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
EP	A2	142663	29-05-1985	AT	E	38555	15-11-1988
EP	A3	142663	03-07-1985	DE	A1	3333907	04-04-1985
EP	B1	142663	09-11-1988	DE	C2	3333907	11-05-1988
				DE	C0	3475100	15-12-1988
EP	A2	881440	02-12-1998	IT	A0	971244	27-05-1997
EP	A3	881440	06-10-1999	IT	A1	971244	27-11-1998
				IT	B1	1292014	25-01-1999
GB	A1	2133867	01-08-1984	GB	A0	8301641	23-02-1983
GB	B2	2133867	11-06-1986	GB	A0	8401145	22-02-1984
US	A	4916912	17-04-1990	EP	A2	364238	18-04-1990
				EP	A3	364238	06-02-1991
				JP	A2	2217766	30-08-1990
US	A	5257506	02-11-1993	DE	C0	69212356	29-08-1996
				DE	T2	69212356	30-01-1997
				EP	A1	505315	23-09-1992
				EP	B1	505315	24-07-1996
				ES	T3	2092079	16-11-1996